ATTACHMENT J-3

TEST PLAN

Integrated Test of the NOx Scrubber Replacement System

For the Arc Jet Steam Vacuum System

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INTRODUCTION

NASA Ames Engineering Division has contracted to have new NOx scrubber equipment installed next to the existing steam vacuum system (SVS) of the arc jet complex. The function of the new system is to remove the nitrogen-oxide (NOx) gases from the process gas exiting the arc jet steam vacuum system (SVS) at the atmospheric exhaust stack. It will replace the existing aging system. This document outlines the detailed tests needed to verify that the new system meets the performance requirements, primarily to meet the air quality discharge requirements. NASA's acceptance of the results of this test series is a condition of the contractor's completing the contract.
Arc jet operations normally produce a process gas stream containing up to 6.3% (63,000 parts per million) gaseous nitrogen oxide (NOx) compounds by volume for periods of less than one hour a few times per day. Local air quality regulations require that NASA exhaust no more than 10 pounds of NOx per day per arc jet facility, when each facility can flow process gas at more than 4 pounds of air per second. This NOx scrubber system must reduce the NOx compound in the process gas before discharge during all arc jet operations. NASA continuously monitors NOx concentration in the exhaust stack and must abide by regulations that limit the overall integrated mass of discharged NOx. Installation and testing of the new equipment must be accomplished in a way that minimizes any interference with ongoing arc jet operations in the complex.

TECHNICAL OBJECTIVES

It is assumed that all functional tests of individual components and of sub-systems of the new NOx scrubber system have been completed successfully without any NOx gas input from the arc jet complex.
The objective of this integrated system test (IST) is to perform a full-function test of the new NOx scrubber. This test requires NASA to operate the arc jets to produce sufficiently large quantity of NOx gas compounds mixed with steam that are input into the new NOx scrubber. The contractor and NASA will evaluate the NOx scrubbing process, especially the amount of NOx at the atmospheric discharge, to verify compliance with all design requirements for the NOx system, and to verify compliance with local air quality permits. NASA will operate arc jets to produce a range of input conditions and test durations.

SCOPE

The contractor has responsibility for ensuring that the system functions according to specifications. NASA will have to work closely with the contractor since the NOx scrubber is highly integrated into the arc jet complex steam vacuum system. The contractor and NASA will cooperatively assess the inlet and outlet NOx mass flow that exist in the process gas stream upon entering and exiting the SVS NOx scrubber system. The NOx concentrations and gas flow rates must be determined using an approved source test method. The source test must be approved by the local air district, the Bay Area Air Quality Management District (BAAQMD). All design requirements of the new NOx system will be evaluated and accepted by NASA before the system is declared operational.

APPLICABLE DOCUMENTS

- Bay Area Air Quality Management District, BAAQMD, Air Quality permit to operate, expires December 1, 2011

TEST DESCRIPTION

5.1 Instrumentation

The following instrumentation will be required and the outputs recorded in engineering units.

NOx Scrubber

- Exhaust NOx concentration analyzer
- Exhaust flow rate

Steam Vacuum System

- E-3 Condenser temperature and pressure

Arc Jet Facilities

- Test gas mass flow rate
- Arc voltage
- Arc current
- Arc heater chamber pressure

The contractor shall record data from all relevant instruments located on the new NOx scrubber. NASA will hire a third-party contractor to independently monitor and verify all NOx measurements and all gas flow rate measurements. All instruments associated with the steam vacuum system and arc jet facilities will be provided by NASA.

As specified under the contract, the contractor will implement a continuous emissions monitoring system on the new NOx scrubber system exhaust. This may include a flow meter to measure the flow rate of the process gas and an analyzer to determine NOx concentration. The emissions monitoring system must be approved by BAAQMD and the gas analyzer must be equipped with a continuous recorder. NASA and the contractor will monitor the calibrated gas analyzer equipment at the atmospheric exhaust stack exiting the NOx scrubber to measure and record the NOx concentration exiting the NOx scrubber and to compute the NOx mass flow rate.

5.2 Arc Jet Test Run Matrix

Operation of the NASA arc jet facilities is what determines the total mass flow rate of process gas as well as the concentration of NOx in the process gas. The NOx scrubber is required to perform over a wide range of input gas flow rates. The requirements were specified by NASA in the contract. In the IST as series of arc jet tests are planned which will encompass the entire range over which the NOx scrubber system must perform. Evaluations will be made at every test condition in the test series. This sequence of runs is defined in Table 1. NASA's air discharge permit specifies total quantities of NOx discharge for each arc jet facility (source), the test matrix will encompass all of the operating arc jet facilities, one at a time.

Table 1 Planned arc-jet run conditions

Run	Current [Ampere]	Air Mass flow rate [kg/s]	Duration [minute]	No. of SVS ejector stages
A	TBD	TBD	TBD	TBD
B	TBD			
C	TBD			
D	TBD			
E	TBD			

5.3 Data Requirements

Real Time Data - Contractor: Monitor the process flows within the NOx scrubber equipment such as pressures and flow rates of cooling water and process chemicals sufficient to verify proper system performance. Monitor the permanent NOx emissions monitoring sensors.
Real Time Data – Environmental Compliance Contractor (hired by NASA): Monitor redundant emissions monitoring sensors temporarily installed for this test to confirm system performance and measurement accuracy.
Real Time Data - NASA: Monitor the standard parameters in the arc jet complex including gas flow rate, arc heater power and bulk enthalpy, and vacuum system performance.
Post-Test Data Reporting – Contractor: All log sheets, analog charts, and digital data files and charts showing system performance will be shared with NASA.
Post-Test Data Reporting – NASA: All log sheets, analog charts, and digital data files and charts showing system performance will be shared with the contractor.

Quality Assurance and Configuration Management plan

The owners of the instrumentation (NASA and the contractor) shall provide documentary evidence of the appropriate operating range and calibration of each component including sensors, signal conditioners and recording devices. Data and results generated by these tests shall be documented and archived according to common standards of configuration management.

Amendments to this Test Plan

In case of any changes to this test plan, the changes will be coordinated between NASA and the contractor before implementing. NASA will place the test plan and associated documentation under Configuration Management control.

Non-conformance procedures

Any non-conformances, including but not limited to out-of range measurements, data loss and test model damage, will be documented by the contractor in a Non-Conformance Report (NCR) and communicated in writing to NASA. NASA will either initiate a Corrective Action Request, or document why no Corrective Action is required. If the non-conformance is of the nature that the contractor can resolve the issue immediately (i.e. minor model damage, data loss, etc.), the disposition can be mutually be agreed upon and the testing resumed.

APPENDIX A

Performance requirements and Inflow conditions for the new NOx scrubber; ref. "SVS NOx Scrubber System Requirements Document," Rev. D dated 09/22/2010 as shown below.

Table A-1. Non-LEAF inflow conditions assuming four operating arc jets

Description	Maximum	Typical	Minimum
Duration of flow	1 hour | 15 min	15 minutes	5 minutes
Frequency of flow	1 per day | 3 per day for 5 days per week; (Note B)	4 per day for 5 days per week	2 per day twice per week
Arc jet run days [per year]	160	160	120
Mass flow rate of test gas [kg/sec]	2.1	0.07 to 0.7	0.02
NOx concentration (at the inlet to the scrubber) [ppmv]	63,000 (Note A)	30,000	1,000
Water vapor content	Saturated (Note C)	Same	Same
Pressure [bar]	1.005	Same	Same
Temperature [°F]	195	Same	Same
SVS Operational Time [per day]	8 hours	6 hours	2 hours

Note A: the NOx concentration is a conservative estimate based on the computed worst-case concentration produced by the arc jet with no removal in the SVS.

Note B: 1 hour runs at a rate of 1 per day; plus 15 minute runs at 3 per day

Note C: the water vapor content is computed to be 1.5 kg of water per kg of dry air at the given temperature and pressure.